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Relative clauses

Processing and acquisition*

William O'Grady

This chapter offers an emergentist perspective on the typology, processing, and acquisition of relative clauses. I begin by outlining the key tenets of an emergentist approach to language, and then offer a proposal for how the two major types of relative clause patterns found in the world's languages (noun-first and noun-last) can be processed without reference to syntactic structure. Two factors in addition to frequency are identified as potential contributors to processing cost: prominence (the salience of the relativized element within the relative clause) and distance (the length of the filler-gap dependency holding between the head noun and the position at which it can be assigned a role within the relative clause). Differences in the relative influence of these factors in noun-first and noun-last languages are then linked to apparent differences in processing cost for subject and direct object relative clauses in the two language types. In the final part of this chapter, these differences are used to build a processing-based account for the acquisition of relative clauses, shedding light on the developmental course typical of this phenomenon in the first years of life.

1. Introduction

The study of relative clauses forces us to confront a series of issues in syntax, typology, and language acquisition that have been at the forefront of linguistics for the last half-century. The purpose of this chapter is to explore those issues from an emergentist perspective. I will begin with a brief characterization of emergentism, followed by an overview of the syntactic properties of relative clauses. I will then turn to the question of how structures with these properties are processed and, finally, to the issue of how they are acquired.

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2. Emergentism

The defining feature of emergentist approaches to natural phenomena is the uncontroversial assumption, articulated by Mills (1930 [1843]) and many others after him (Thelan & Smith 1994, Kelso 1995, Holland 2000, Morowitz 2002), that the interaction of simple elements and phenomena can yield systems and effects of a qualitatively different and more complex nature. Bodies of water have properties not manifested in single molecules of water, or in the hydrogen and oxygen atoms of which those molecules are composed. Economies have properties that arise solely from the way in which members of a community interact with each other and with the circumstances in which they find themselves. And so on. A core assumption of emergentist work in cognitive science is that the human mind works this way too.

The goal of emergentist accounts of language is extraordinarily challenging: to make sense of the complexity and variety of grammatical phenomena by reference to the interaction of factors that are not themselves inherently grammatical in character. Most work in this area (see O'Grady 2008b,c for a brief overview) assigns a *de facto* primacy to experience, pragmatics, processing, or cognition, to name just four possibilities. However, it should be understood that this is just an initial research strategy, adopted for practical reasons, and that many different factors and propensities, interacting with each other, are ultimately responsible for why language is the way that it is.

The particular focus that I adopt gives primacy to the processing mechanisms that implement the relationship between form and meaning in the course of speech by establishing and strengthening associations between sound waves and phonemes, between concepts and morphemes, between events and linear strings of words, and so on. Two issues immediately arise, one having to do with how the processor works and the other having to do with the types of elements on which it operates.

Taking the latter issue first, I assume – for the sake of being able to proceed at all – that various acoustic and semantic notions (voice onset time, agency, aboutness, etc.) are 'available in advance' for the mappings computed by the processor. Thus voice onset time can be used to map a particular acoustic stimulus onto, say, /b/ rather than /p/; agency can be used to map a particular referent onto the appropriate argument position in a verb's conceptual structure; and so on. See O'Grady (2008a) for some discussion of this point.

As for processing itself, two propensities appear to be of special relevance. First, the processor manifests a well-documented sensitivity to frequency, which shapes the acquisition and use of language in many significant ways (Bybee & Hopper 2001, Ellis 2002, Gennari & MacDonald 2008, Wells et al. 2008, Lieven 2010). As we will see in due course, the influence of frequency is manifested in the processing and acquisition of relative clauses too.

The second propensity, also widely acknowledged, involves a preference for operations and representations that minimize the burden on ‘working memory’ – a cover term for the neural activation required to maintain the representations and carry out the computations associated with language use. Although the precise effects of this propensity are still a matter of conjecture, there is evidence that key properties of many ‘core’ syntactic phenomena – agreement, locality, binding, control, filler-gap dependencies, scope, and so forth – are shaped by working memory considerations (Hawkins 2004; O’Grady 2005, 2010a). Relative clauses offer an opportunity to further explore the promise of this explanatory strategy.

3. The syntax of relative clauses

For the purposes of this discussion, I will assume that the bracketed phrases exemplified below constitute core instances of the relative clause category.

(1) English:

the man [_s that you met _]

(2) Persian:

mærd-i [_s ke **ura** molaqat kærdid]
 man-RelMrkr that him meet AUX.PST.2SG
 ‘the man that you met’

Relative clauses manifest three crucial properties.

- They are instances of an event-denoting (sentential) category.
- Some component of that event is ‘under-represented’ within the relative clause itself – it is either entirely absent (there is a ‘gap’, as in English) or it is encoded as a resumptive pronoun, as in Persian.
- That under-represented element picks up its interpretation from the nominal with which the relative clause is associated (e.g., *man*, the so-called ‘head noun’ in the examples above).

Taken together, these three features create a relationship between the relative clause and the head noun that I will call ‘aboutness’ for lack of a better term, following Kuno (1976). Put simply, the relative clause says something *about* the intended referent of the head noun, attributing to it the property of fitting into the event in a way that can be inferred by matching it to the under-represented element. Thus in the case of (1) and (2) a particular man has the property of being the person who the addressee met in the event denoted by the relative clause.

In most versions of Principles and Parameters theory, these intuitions are implemented via operations that (a) build an elaborate hierarchical syntactic representation, (b) move a *wh* operator (often invisible) from a clause-internal argument position to the pre-clausal 'specifier of CP' position, and (c) link the *wh* operator (and the gap created by its movement) with the head noun.

- (3) a. Creation of a complex syntactic representation (simplified):
 People [_{CP} that [_{IP} dogs [_{VP} trust *wh*_i]]] are likeable.
- b. Movement of the *wh* operator, leaving behind a gap ('trace'):
 People [_{CP} *wh*_i that [_{IP} dogs [_{VP} trust _i]]] are likeable.

- c. Linking of the fronted *wh* operator with the head noun ('predication'):
People_i [_{CP} *wh*_i that [_{IP} dogs [_{VP} trust _i]]] are likeable.

Such a system of operations and representations, constrained by abstract principles of Universal Grammar, is incompatible with the emergentist program that I propose. Indeed, on the view I adopt, the processor does not even compute tree-like syntactic representations – syntactic structure in the conventional sense does not exist.¹ Instead, the processor creates an incremental mapping between form and meaning, dispensing with each component of the sentence as soon as it can be interpreted, rather than building the hierarchical structures typical of traditional syntactic representations. An example, simplified for the sake of exposition, will help illustrate what I have in mind.

In response to a sentence such as *Dogs trust people*, the processor reacts as follows, drawing on information about individual words stored in the lexicon and on previously established routines that treat a pre-verbal NP as the verb's first argument (agent) and a post-verbal NP as its second argument (patient).

- (4) Dogs trust people.
- a. Upon encountering the nominal *dogs*, the processor assigns it an interpretation (represented here as the index *d*) and dispenses with the nominal itself.
- dogs* ← *form*
d ← *interpretation*

1. This is a somewhat more radical view than the one expressed in *Syntactic Carpentry* (O'Grady 2005), in which I proposed that binary-branching syntactic representations might exist as a residual record of the manner in which a simple efficiency-driven processor goes about analyzing sentences. See O'Grady (2010b) for more extensive discussion of the explanatory potential of syntax-free processing.

- b. Upon encountering *trust*, the processor projects a conceptual structure (represented here as a predicate – argument grid complex) and discards the word itself. Then, based on the remembered pre-verbal position of *dogs*, that word’s referent is used to resolve the verb’s first argument dependency. The second argument dependency, represented here as *y*, is of course unresolved at this point.

~~dogs~~ trust

[TRUST]
[< *d* *y* >]

↑

first argument dependency is resolved by the referent of dogs

- c. Upon encountering the nominal *people*, the processor assigns it an interpretation (represented by the index *p*), and dispenses with the nominal itself. Based on the nominal’s position (post-verbal), its referent is used to resolve the verb’s second argument dependency.

~~dogs~~ ~~trust~~ people

[TRUST]
[< *d* *p* >]

↑

second argument dependency is resolved by the referent of people

As can be seen here, simple computational operations map a sentential form onto an event representation, without the mediation of syntactic structure.

As the next example illustrates, a slight extension of these procedures permits the interpretation of relative clauses such as *people (that) dogs trust*.

(5) people [dogs trust _]

- a. The processor encounters the nominal *people*, interprets it, and dispenses with the nominal itself.

~~people~~

p

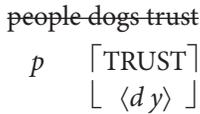
- b. The processor encounters the nominal *dogs*, interprets it, and discards the nominal.

~~people~~ ~~dogs~~

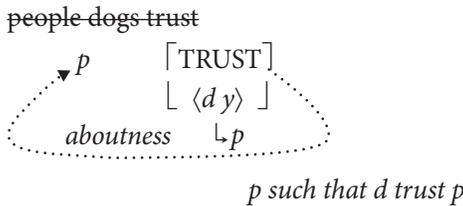
p *d*

- c. The processor encounters the transitive verb *trust*, and projects a conceptual structure. Based on the remembered pre-verbal position of *dogs*, its referent is used to resolve the verb’s first argument dependency.

The verb's second argument dependency, represented here as y , is unresolved at this point.



- d. In the absence of an opportunity to resolve the verb's second argument dependency in the usual way (by means of a nominal to the right, as in (4)), the processor invokes a routine that exploits the open dependency to create an aboutness relationship between the trusting propensity of dogs on the one hand and the referent of *people* on the other. This gives the interpretation ' p such that d trust p ' ('people such that dogs trust them').²



A terminological point is in order before proceeding. Although I use the terms 'subject,' 'direct object,' and 'gap' for expository purposes, this practice does not imply a commitment to traditional syntactic representations. In the sense in which I use these terms, a subject is simply the first argument in a verb's conceptual structure, the direct object is the second argument, and 'gaps' should be thought of as unresolved argument dependencies, not empty syntactic positions.

Let us now turn to the question of how different types of relative clauses are processed – a crucial prelude to understanding how they are acquired, as we will see in due course.

4. The processing of relative clauses

The vast majority of research on the processing of relative clauses in English has focused on the contrast exemplified in (6), in which the verb takes two animate arguments.

2. In formal terms, the property denoted by the relative clause can be expressed as follows, using 'lambda notation': $(\lambda x [\text{trust}(\text{dogs}, x)] - \text{'the property of being an } x \text{ such that dogs trust } x')$.

- (6) a. Subject relative clause:
 the student [that _ met the teacher]
 b. Direct object relative clause:
 the student [that the teacher met _]

There is a broad and long-standing consensus that subject relatives such as (6a) are easier to process than their direct object counterparts (e.g., Wanner & Maratsos 1978, Carpenter et al. 1994, Gibson 1998: 2, Caplan & Waters 2002, Gennari & MacDonald 2008: 162–64, and the many references cited therein). Recently, however, this consensus has been challenged by experimental evidence that this asymmetry is neutralized when the direct object relative clause modifies an inanimate head and/or has a pronominal subject, as in the example below (Traxler et al. 2002, 2005; Mak et al. 2002, 2006; Reali & Christiansen 2007; Gordon et al. 2001, 2002).

- (7) the apple [that you ate _] was green.
 ↑ ↑ ↙
 inanimate pronoun gap
 head noun subject

It is well known that direct object relative clauses show a strong statistical tendency to have inanimate heads (Reali & Christiansen 2007, Gennari & MacDonald 2009), consistent with the general cross-linguistic tendency for direct objects to have inanimate referents (Aissen 2003). Might direct object relatives such as (6b), with an *animate* head, be difficult simply because they are statistically unusual?

It is difficult to generalize from the ease of (7) to the difficulty of (6b). Because patterns such as (7) are semantically non-reversible, their interpretation can be inferred without reference to syntactic considerations (a person can eat an apple, but not vice versa). For this reason, they arguably do not call upon the full resources of the processor, and are therefore not as informative as they might initially appear to be.

Matters are further complicated by two additional facts. First, a subject advantage re-emerges in English in patterns such as (8), where both the subject relative clause and the direct object relative clause have an inanimate head although subject relatives of this type are infrequent. (Reali & Christiansen 2007: 15ff).

- (8) a. Subject relative clause with inanimate head (unusual):
 the studies [that _ motivated it]
 b. Direct object relative clause with inanimate head (common):
 the studies [that it motivated _]

Second, as we will see shortly, in some languages direct object relatives are apparently no more difficult to process than subject relatives, even when they have an *animate* head.

These considerations suggest that more than frequency is relevant to understanding the difficulty of certain types of relative clauses. But what might those other factors be? In trying to answer this question, I will assume the essential correctness of the constraint satisfaction approach to processing, a staple of emergentist work on syntactic computation (e.g., Traxler et al. 2005, Reali & Christiansen 2007, Gennari & MacDonald 2009, among many others). On this view, a myriad of interacting factors determines processing cost. Statistical tendencies have their place, but so do other sorts of effects. I will focus here on two factors that appear to be of special relevance to relative clauses, namely the prominence of subject arguments and the cost of maintaining filler-gap dependencies.

Prominence

The relevance of prominence stems from the observation that relative clauses must be about the referent of the head noun and that the construal of an aboutness relationship is made easier when that referent corresponds to a salient component of the relative clause, especially its subject. (I use the term 'salience' in the broadest possible sense to include attentional, pragmatic, perspectival, and discursal factors.)

Proposals along these lines have been put forward by Schachter (1973: 44), who attributes the prominence of the subject to foregrounding, by MacWhinney (2005), who invokes the notion of 'perspective,' and by Kuno (1976), who makes reference to topicality (see also Givón 1984: 138, Mak et al. 2006, and the references cited there). The insight can be summarized this way:

- It is difficult to use a relative clause as a restrictor if it is internally focused on an entity other than the referent of the head noun (e.g., Hsu, Hermon & Zukowski 2009: 350).
- Clauses tend to be internally focused on the referent of their subject, the most prominent argument.
- Thus it is easiest to use a relative clause as restrictor when the head noun corresponds to the subject argument.

From a processing perspective, the prominence factor can be stated informally as follows.

(9) The prominence factor

The ease with which the processor establishes an aboutness relationship with a nominal is proportional to the prominence of that nominal's referent within the relative clause. (A referent functioning as subject within the relative clause is most prominent, a referent functioning as direct object is next most prominent, and so on.³)

The distance between filler and gap

A second factor that has often been suggested as relevant to the processing of relative clauses involves the length of the so-called 'filler-gap dependency' that holds between the modified nominal and the position at which it can be associated with the verb's conceptual structure. It has been repeatedly demonstrated that such dependencies place a burden on the processor. As Hawkins (2004: 173) observes, 'there appears to be a consensus [that] ... filler-gap dependencies are hard to process, and [that] they are characterized by a heightened processing load and a constant effort to relate the filler to the appropriate [resolution] site... Doing so is not easy...' See also Goodall (2004: 102).

Of the various metrics that have been proposed for calculating the cost of such dependencies, the most promising for our purposes is an idea developed by Gibson (1998); see also Warren & Gibson (2002) and Lewis, Vasishth & Van Dyke (2006). The key insight, summarized by Grodner & Gibson (2005: 262), is simply this: 'because mental representations become degraded over time or with more input ..., the difficulty of [a] computation is, in part, determined by the amount of lexical material intervening between the [filler and the gap].'⁴ Especially crucial in this regard are NPs and verbs that introduce new discourse referents (essentially, new entities and events). Consider in this regard the contrast between subject and direct object relative clauses in (6), repeated here as (10).

3. Might there be languages in which the subject is not the verb's most prominent argument? It is commonly claimed that ergative language work this way, and that the direct object is more prominent and/or easier to process than the subject (Manning 1996: 87, Carreiras et al. 2010: 90). Interestingly, such languages are more likely to permit relativization of the direct object than the subject (Liao 1999/2000). Moreover, Carreiras et al. offer evidence from Basque that this typological tendency aligns with processing cost in that direct object relatives in ergative languages are easier to process than their subject counterparts – presumably for reasons relating to prominence.

4. Other well known ideas make reference to the 'depth' of the gap in syntactic structure (O'Grady 1997: 135ff) and the size of a syntactically defined 'filler-gap domain' (Hawkins 2004: 177ff). Neither of these ideas is compatible with the assumption that the processor does not build syntactic representations.

- (10) a. Subject relative clause:
 the student [that _ met the teacher]
 └─── 0 ──┘
- b. Direct object relative clause:
 the student [that the teacher met _]
 └────────── 1 2 ─────────┘

Consistent with its processing advantage, the filler-gap dependency in (10a) can be resolved at minimal cost to working memory, as the sole intervening element (the complementizer *that*) does not introduce a discourse referent. In contrast, two elements with new discourse referents – the NP *the teacher* and the verb *meet* – intervene between the filler and the gap in the direct object relative clause in (10b).⁵ The distance factor can be informally paraphrased as follows.

- (11) The distance factor
 The difficulty of processing a relative clause increases with the length of the filler-gap dependency (calculated in terms of intervening new discourse referents).

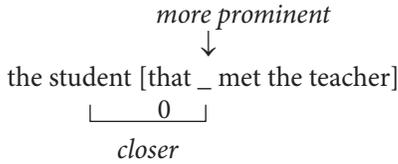
Although Gibson assumes the existence of conventional syntactic representations, his metric can just as easily be implemented by reference to the relative immediacy with which the filler-gap dependency can be resolved – at the verb in the case of subject relatives, but only after processing both the subject NP and the verb in the case of direct object relatives. Within the syntax-free computational system that I propose, the effect of these intervening elements comes simply from the fact that they postpone resolution of the filler-gap dependency, thereby increasing the burden on working memory.⁶

This now forces us to confront a new problem, namely the existence in English of a confound between the prominence and distance factors: as illustrated in (12), the maximally prominent subject position is closer to the head noun and the less prominent direct object position is more distant.

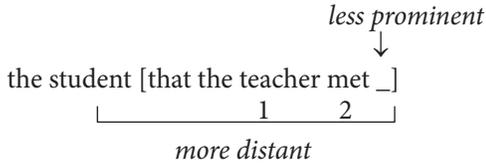
5. Another version of the distance hypothesis proposes that patterns such as (10b) are made difficult by the fact that the filler-gap dependency is interrupted by an NP with the same semantic and syntactic properties as the filler: both *the student* and *the teacher* are animate lexical NPs (Lewis et al. 2006: 449, Friedmann et al. 2009, Lee et al. 2010).

6. Indeed, as Lewis et al. (2006: 452) independently note, the right metric for processing difficulty may be time-related rather than distance-related.

- (12) a. Subject relative clause:



- b. Direct object relative clause:



The problem that we need to confront at this point comes down to this: is the comparative processing ease of subject relative clauses in English due to the prominence effect, the distance effect, or a combination of the two? Data from Chinese help shed light on this question.

Chinese

Chinese is like English in employing SVO order, but unlike it in placing its relative clauses *before* the noun that they modify. (The morpheme *de* marks a clause that combines with a nominal.)

- (13) a. Subject relative clause

[_ yaoqing fuhao] de guanyuan
invite tycoon DE official
'the official who invited the tycoon'

- b. Direct object relative clause

[fuhao yaoqing _] de guanyuan
tycoon invited DE official
'the official who the tycoon invited'

What makes Chinese relative clauses especially intriguing is the fact that the prominence and distance factors are no longer confounded – subject relative clauses such as (13a) enjoy only a prominence advantage, whereas direct object relatives such as (13b) enjoy only a distance advantage.

Let us begin by considering how a subject relative clause such as (13a) is processed.

Table 1. Prominence and distance in English and Chinese

	Subject relatives	Direct object relatives
English	prominence advantage & distance advantage	no advantage
Chinese	prominence advantage	distance advantage

(14) [_ yaoqing fuhao] de guanyuan
 invite tycoon DE official
 ‘the official who invited the tycoon’

- a. The processor encounters the verb *yaoqing* ‘invite’, interprets it, and projects a conceptual structure involving two still-to-be identified arguments, represented here as *x* and *y*.

yaoqing
 invite
 [INVITE]
 [< x y >]

- b. The nominal *fuhao* ‘tycoon’ is encountered and assigned an interpretation (represented here as *t*). By virtue of its linear position, its referent is used to resolve the verb’s second argument dependency.

yaoqing fuhao
 invite tycoon
 [INVITE] t
 [< x t >]

- c. Upon encountering the head noun *guanyuan* ‘official’ and assigning it an interpretation (represented by the index *o*), the processor uses the verb’s unresolved first-argument dependency to establish the aboutness relation typical of relative clauses.

yaoqing fuhao de guanyuan
 invite tycoon official

an *o* such that *o* invited *t*

As can be seen here, resolution of the argument dependency corresponding to the subject ‘gap’ is delayed, at least to a small degree, by computation of the verb’s second argument, with its new discourse referent (step b) – a manifestation of the distance factor.

Interestingly, no comparable delay takes place in the interpretation of a direct object relative clause.

(15) Direct object relative clause

[fuhao yaoqing_] de guanyuan
 tycoon invited DE official
 'the official who the tycoon invited'

- a. The nominal *fuhao* 'tycoon' is encountered, interpreted, and dispensed with.

~~fuhao~~
~~tycoon~~
t

- b. The verb *yaoqing* 'invite' is encountered and interpreted; by virtue of the remembered linear position of *fuhao* 'tycoon', its referent is used to resolve the verb's first argument dependency. The verb's second argument dependency, represented here as *y*, remains unresolved.

~~fuhao~~—~~yaoqing~~
~~tycoon~~—~~invite~~
t [INVITE]
 [< *t y*]

- c. In the absence of an opportunity to resolve the verb's second argument dependency in the usual way (by means of a nominal to its immediate right), the processor creates an aboutness relation between the inviting event initiated by the tycoon on the one hand and the referent of *guanyuan* 'official' on the other, giving the usual relative clause interpretation.

~~fuhao~~—~~yaoqing~~ de ~~guanyuan~~
~~tycoon~~ invite — official

[INVITE]
 [< *t y*]
 ↓ *o*

an o such that t invited o

In this case, no computational operation involving a new discourse referent intervenes between the discovery of the unresolved argument dependency (at the verb) and its resolution in step (c) as part of the routine that builds a direct object relative clause. We thus have a potentially revealing contrast between English and Chinese relative clauses. Whereas prominence and distance collude to predict a processing preference for subject relative clauses in English, the two factors pull in

Table 2. Preference factors relevant to relative clauses in English and Chinese

	prominence	distance
English	favors subject relative	favors subject relative
Chinese	favors subject relative	favors direct object relative

opposite directions in Chinese – prominence favors subject relatives, whereas distance confers an advantage on direct object relatives.

We can now ask which factor, if either, is stronger.

In contrast to English, where there is a strong consensus in favor of a processing preference for subject relatives, the results reported so far for Chinese have been mixed. Drawing on data from a self-paced reading task, Hsiao & Gibson (2003) report that native speakers of Chinese read the N – V string in direct object relative clauses faster than the V – N portion of subject relatives. Using a similar technique, B. Chen, Ning, et al. (2008) also report a faster reading time for direct object relative clauses, but only for participants with low memory spans; no difference at all was found for those with high memory spans.⁷ In contrast, Lin & Bever (2006: 256) report faster reading times on the head noun for subject relative clauses, as do Z. Chen, Li, et al. (2010).

Recent work by Gibson & Wu (2010) adopts a different tack, focusing on a potentially crucial idiosyncrasy of Chinese relative clauses. Because Chinese is a 'pro-drop' language and because its relative clauses are pre-nominal, temporary ambiguities can arise. Thus to take a concrete example, the string *yaoqing fuhao* 'invite tycoon' from (14), repeated below as (16), could easily be a root clause whose missing subject argument is a null pronoun with a discourse referent – hence 's/he invited the tycoon.' Only after the head noun is encountered is it possible for the processor to zero in on the relative clause interpretation.

up to this point, the status of the initial clause is unclear

↓

- (16) [_ yaoqing fuhao] ... de guanyuan
 invite tycoon DE official
 'the official who invited the tycoon'

In order to guard against the possibility that clause type ambiguity might neutralize or otherwise distort the distance factor, Gibson & Wu devised a self-paced reading task in which the test items (subject and direct object relative clauses) were

7. Neither study found a reading time difference at the head noun (*guanyuan* 'official' in the examples above) – the point at which the filler-gap dependency is presumably identified and resolved.

presented in contexts that made their status as modifiers clear to the 40 adult subjects in the experiment.⁸ The results pointed toward significantly shorter reading times at the head noun for direct object relatives compared to their subject counterparts – apparent evidence that the distance effect overrides any prominence effect in these cases. (A less spectacular result is reported by Lin 2008: 824, who found that preparing participants for a relative clause reduced reading times for direct object relatives, but not enough to make them faster than subject relatives.)

If Gibson & Wu's report of a direct object advantage for Chinese relative clauses stands up, it would establish a surprisingly strong distance effect in that language, especially in light of the relatively modest distance contrast (just one word) between subject and object relatives. Indeed, in order to accommodate the direct object advantage that they report, it is necessary to assume that distance overrides not only prominence (the subject is the more prominent argument), but also animacy expectations (the normally inanimate direct object argument is animate in the test items) and frequency (Hsio & Gibson 2003 report that subject relatives are more frequent than object relatives in Chinese).

A further issue has to do with whether there is an advantage in favor of either type of pattern in production, in which participants have to create their own relative clauses rather than simply interpret those created for them by the experimenter. Hsu et al. (2009: 340) report a strong preference for subject relative clauses in an elicited production task that they conducted, with their 10 adult participants successfully producing subject relatives 95% of the time, compared to just 82.5% for direct object relatives in cases where the head is a free-standing NP. The contrast was far more pronounced (86.8% and 38.7%) in Hsu et al.'s 21 child participants (mean age 4;8). This raises the possibility, which I will not explore further here, that prominence might have a stronger effect in production than in comprehension.

Japanese and Korean

Japanese and Korean resemble Chinese in having pre-nominal relative clauses. Crucially, however, Japanese and Korean are verb-final languages, which means that 'gaps' – whether of the subject or direct object type – can presumably not be

8. A further factor to consider in the case of Chinese is that direct object relatives manifest the canonical 'agent–action–patient' order typical of basic sentences. This could well facilitate interpretation of the direct object relative clause (e.g., Hsiao & Gibson 2003: 14).

	<i>agent</i>	<i>action</i>	<i>patient</i>	
(i)	[fuhao	yaoqing	_]	de guanyuan
	[tycoon	invited		DE official
	'the official who the tycoon invited'			

confirmed until the end of the clause, when the verb's conceptual structure is computed. Consider first the case of a subject relative clause in Japanese.

(17) Subject relative clause:

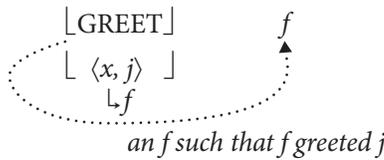
[~~_~~ John-o mukae-ta] tomodachi
 John-ACC greet-PST friend
 'the friend who greeted John'

- a. At the point where the verb is encountered, its first argument (represented by x) is unknown, but its second argument can be equated with the referent of the previously computed accusative-marked *John* (represented as j).

{~~John-o mukae-ta~~}
~~John-ACC greet-PST~~
 j [GREET]
 [$\langle x, j \rangle$]

- b. Upon encountering *tomodachi* 'friend,' the processor creates an aboutness relation by interpreting that nominal as the verb's first argument.

~~John-o mukae-ta tomodachi~~
~~John-ACC greet-PST friend~~



an f such that f greeted j

Now consider a direct object relative clause.

(18) Direct object relative clause:

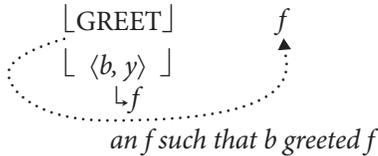
[Bob-ga ~~_~~ mukae-ta] tomodachi
 Bob-NOM meet-Pst friend
 'the friend who Bob met'

- a. At the point where the verb is encountered, its first argument dependency can be resolved by the referent of the previously computed nominative-marked *Bob* (represented as b), but its second argument dependency (represented as y) is yet to be resolved.

{~~Bob-ga mukae-ta~~}
~~Bob-Nom greet-PST~~
 b [GREET]
 [$\langle b, y \rangle$]

- b. Upon encountering *tomodachi* ‘friend,’ the processor creates an aboutness relation by interpreting the nominal as the verb’s second argument.

Bob-ga mu.kae-ta — tomodachi
 Bob-Nom greet-PST friend



The key observation here is that no operation involving a new discourse referent intervenes between the identification of the unresolved argument dependency (at the verb) and the discovery of the head noun (right after the verb) in either type of relative clause. If this is right, then there should be no distance effect in Japanese and Korean relative clauses – just the possibility of a prominence effect favoring the subject. In fact, there is evidence pointing toward an effect of this very type, although the matter is far from resolved.

Miyamoto & Nakamura (2003) conducted a self-paced reading task involving 24 adult native speakers of Japanese, using subject and direct object relative clauses of the usual sort. They found no significant difference in reading time within the relative clause itself, as predicted, since the open argument dependency is encountered at the same point in both patterns (at the verb). But they did uncover a significantly faster reading time at the head noun for subject relative clauses. This suggests a prominence effect – it is harder to construe a relative clause as being about the referent of the direct object than the referent of the more prominent subject.

This is arguably a weak effect, however. In a self-paced reading experiment that included contexts designed to create an expectation for relative clauses, Ishizuka et al. (2006) uncovered no significant difference in the processing time at the head noun in subject and direct object patterns.⁹ In earlier work without these contexts, Ishizuka (2005: 151) reported faster reading times at the head noun for subject relatives, but the advantage was significant only in the item analysis.

The situation in Korean is also less than clear. In an investigation of relative clause processing by adults, Kwon, Polinsky & Kluender (2006) uncovered faster reading times for subject relatives at the head noun, but no difference at all within the relative clause itself. (The subject advantage was subsequently confirmed in an

9. However, there was a difference at the verb in favor of direct object relatives, which suggests a processing preference for unresolved direct object dependencies over their subject counterparts. It is unclear why this is so, or whether it is specific to relative clauses.

eye-tracking experiment conducted by Kwon and colleagues 2010). Crucially, Kwon et al. (2006) also report a subject advantage for null arguments in adverbial clauses, which do not involve the type of filler-gap dependency found in relative clauses. This may point toward a preference for subject prominence in the interpretation of 'missing' arguments in general.

Summary

In sum, there appears to be a striking cross-linguistic difference between noun-first and noun-last languages with respect to the difficulty of subject and direct object relative clauses that contain two animate arguments. On the one hand, as a wide range of experimental work has repeatedly shown, noun-first languages such as English manifest a robust advantage in favor of subject relative clauses, in both production and comprehension, regardless of methodology and task. On the other hand, it also seems clear that noun-last languages such as Chinese, Japanese and Korean exhibit no such preference. Possible signs of a subject advantage for relative clauses in those languages appear to be weak and task-dependent, and are countered by conflicting results from other experiments, some even suggesting a direct object advantage. Taken together, these results suggest that the preference found in English reflects the synergistic interaction of the prominence and distance factors, which act in concert to create a stronger bias in favor of subject relative clauses than would arise if only prominence were in play.

Nonetheless, a great deal remains to be understood, particularly with respect to the effect of prominence. Whereas work by Gibson and his colleagues has helped narrow down the precise factors underlying the distance effect, there has been no comparable attempt to study prominence. It remains to be determined to what extent its effects might vary in response to contextually induced modifications of the topicality of one or the other of the verb's arguments, and whether comprehension and production are affected to the same degree.

5. The acquisition of relative clauses

Finally, we come to the question of acquisition. Two separate problems require attention. The first has to do with why children follow the particular developmental path that they do as they progress from a state of inarticulate incomprehension to full proficiency in the language(s) to which they are exposed. Let us call this the 'path problem.' The second question has to do with how children are able to bring the acquisition process to a close at the right time, avoiding overgeneralizations

that go beyond what their language permits; I will call this the ‘closure problem.’ Let us consider each problem in turn.

The path problem

In considering the question of why developmental paths emerge in the course of language acquisition, I will build on the simple intuition – correct almost by definition – that children master less difficult patterns before more difficult ones. The challenge, of course, is to define difficulty in a non-circular way.

Processing cost offers a promising possibility: all other things being equal, the following straightforward relationship can be expected to hold between processing complexity and development.

(19) The Difficulty Principle

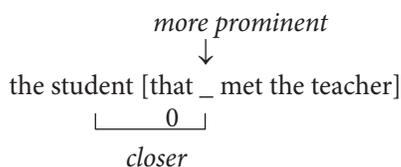
Processing difficulty should impede use and mastery of particular form-meaning mappings.

But what contributes to processing difficulty?

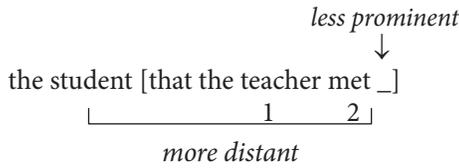
It is widely acknowledged that frequency can facilitate or impede processing difficulty – in the absence of confounding factors, a more frequently activated processing routine will be better entrenched and easier to use than a competitor that is less commonly called upon. But frequency cannot be the whole story. As we have seen, direct object relative clauses with animate heads (e.g., *the student that the teacher met*) are universally infrequent, yet there are clear differences across languages in terms of their degree of difficulty: they appear to be consistently harder to process than subject relative clauses in English, but apparently not in Chinese, Japanese, or Korean.

Much of this chapter has concentrated on such contrasts and on the possibility that they reflect the interaction of two factors independent of frequency – prominence (the ease with which the relative clause can be construed as being ‘about’ the head noun) and distance (the length of the filler-gap dependency). In a noun-first language such as English, these factors appear to conspire to make direct object relative clauses harder to process than their subject counterparts.

(20) a. Subject relative clause:



b. Direct object relative clause:



The Difficulty Principle therefore predicts that English subject relative clauses should be mastered before (or at least no later than) their direct object counterparts. This prediction appears to be correct, as numerous studies using a variety of methodologies have reported for both production and comprehension (e.g., O'Grady 1997: 174ff, Diessel & Tomasello 2005, Friedmann et al. 2009, and the references cited therein). Similar results have been reported for other noun-first languages (Arosio et al. 2006, Arnon 2005).

An important proviso should be reiterated at this point: the predicted disadvantage for direct object relative clauses holds only for cases where both arguments are animate lexical NPs. As observed in Section 3 above, the processing difficulty associated with direct object relatives is mitigated, and perhaps even eliminated, in patterns such as (21), in which the subject is pronominal and therefore does not introduce a new discourse referent, and the direct object is inanimate, offering a pragmatic clue to the clause's interpretation and minimizing the need for syntactic processing.

(21) the apple [that she ate _]

In the absence of a processing disadvantage for direct object relative clauses of this type, there should be no developmental delay either. This is precisely what we find. As Kidd, Brandt, et al. (2007) document based on corpus data and the results of an elicited imitation task involving 3–4-year-old English- and German-speaking children, learners do as well on direct object relatives such as (21) as on subject relatives (pp. 887–88).

Now let us consider the case of noun-last languages, in which either there is no distance effect (Japanese and Korean), or the distance effect and the prominence effect pull in opposite directions (Chinese). From a processing perspective, subject relatives in such languages should enjoy at best a weak advantage (due to prominence) – and perhaps no advantage at all, even when both arguments are animate. This in turn predicts a developmental profile in which there is little, if any, advantage for subject relative clauses.

One piece of evidence in support of this prediction comes from Ozeki & Shi-rai's (2007a,b) analysis of longitudinal data for five Japanese children (1;00 to 3;11), which found that subject, direct object and oblique relative clauses are used with

the same approximate frequency from the earliest stages of acquisition. At least one comprehension study involving relative clauses with two animate arguments has yielded an equally suggestive finding: in Suzuki's (2011) picture selection experiment, performance was significantly better on direct object relatives (83% correct), compared to subject relatives (60.7% correct), but this difference disappeared once children's knowledge of case markers was taken into account.

Also suggestive are the facts from Cantonese, whose relative clauses resemble those of Mandarin Chinese and should therefore be susceptible to the competing effects of prominence and distance. Based on a longitudinal study of three Cantonese-English bilingual children, Yip & Matthews (2007: 287) report earlier use of direct object relatives by two of the children and the simultaneous emergence of subject and direct object relatives in the speech of one child. To date, the results from comprehension studies involving relative clauses with two animate arguments appear to be somewhat contradictory, with Chan (this volume) reporting a preference for direct object relatives in a picture-pointing task and Lau (2010) reporting the reverse preference in the same sort of task.

Overall then, the results of acquisition studies appear to align quite well with the results of adult processing studies, revealing a strong preference for subject relatives in the case of noun-first languages and the lack of such a preference in the case of noun-last languages. This is just what one would expect if processing difficulty shapes the course of language development. On this view, the path problem is reduced to processing considerations – a desirable result.

The closure problem

A paradigm example of the closure problem arises in the case of languages that allow only certain types of relative clauses (say, only subject relatives and direct object relatives): somehow children learning such languages must avoid overgeneralizing to the conclusion that relative clauses of all types are permitted. Welsh is a case in point, as illustrated in the following examples from Keenan & Comrie (1977: 70).

- (22) a. Subject relative clause
 y bachgen [a oedd yn darllen _]
 the boy Rel was PRT reading
 'the boy who was reading'
- b. Direct object relative clause
 y stori [a ddarllenodd y bachgen _]
 the story Rel read the boy
 'the story that the boy read'

- c. Indirect object relative clause (acceptable only with resumptive pronoun)

y bachgen [y rhoddais y llyfr iddo]
 the boy Rel I.read a letter to.him
 'The boy that I read a letter to'

The challenge for learners of Welsh is to resist the temptation to generalize from the form of subject and direct object relative clauses to the acceptability of gap-type indirect object relatives.

On a processing-based approach to language, the closure problem can be unified with the question of why there are languages that allow only certain types of relative clauses in the first place. The leading idea, put forward by Hawkins (2004: 192ff, 266) and O'Grady (2005: 203ff, 214ff), is that processing factors create a continuum of difficulty along which there are certain natural 'break points.' In the case of relative clause patterns in noun-first languages such as Welsh, two factors create a break point between subject and direct object relative clauses on the one hand and indirect object relatives on the other. The first is prominence (on standard assumptions indirect objects are less prominent than subjects or direct objects; see, e.g., Kuno 1976, Givón 1984: 138). The second factor involves the length of the filler-gap dependency, which is greater in Welsh for indirect object relatives than for direct object or subject relatives.

The key idea is thus straightforward: the harder it is for the processor to compute an aboutness relationship between a particular type of relative clause and the referent of the head noun (due to the effects of distance, prominence, or both), the less likely a language learner is to generalize to such a construction. If this is on the right track, the closure problem can also be reduced to a processing phenomenon, just like the path problem.

6. Concluding remarks

This chapter has been about the acquisition of relative clauses; yet the actual discussion of acquisition makes up less than 20% of the chapter's content. This is appropriate, I believe.

A key feature of the emergentist approach to language that I have been outlining is that it does not require a separate theory of language acquisition – much of what happens in the course of development is simply a side-effect of processing (O'Grady 2011). The external factor of frequency clearly has some role to play: it is widely agreed that familiarity facilitates processing by increasing the activation level (and hence the accessibility) of particular routines. However, there is reason to

believe that the key to understanding the acquisition of relative clauses lies in factors other than frequency-induced familiarity. Two effects seem especially relevant.

The first involves the prominence of the referent of the head noun within the relative clause – whether it is subject (first argument), direct object (second argument), and so on, in accordance with the well established hierarchy first put forward by Kuno (1976). The greater the referent's prominence, the more easily the processor can establish the aboutness relationship that is essential to the use of relative clauses.

The second factor involves the length of the filler-gap dependencies that unfold in the course of incremental processing. Here, as we have seen, there is reason to think that the number and type of elements that intervene between the filler and the point at which it can be associated with a position in the verb's conceptual structure (the 'distance factor') affect processing cost in the expected way.

The key claim in all of this is that the very factors relevant to an account of processing difficulty (prominence and distance) are also crucial to language acquisition, offering answers to the question of why learners follow the particular developmental course that they do (the path problem) and the question of how they are able to bring the acquisition process to a close without overgeneralizing beyond the patterns permitted in their language (the closure problem). As we have seen, processing cost defines a scale of difficulty that predicts the course of development for relative clauses while at the same time offering an impediment to innovations that go beyond the subset of relative clause types to which the learner is exposed.

In closing, it is important to acknowledge that processing is far from a trivial phenomenon. It is subject to a myriad of interacting influences beyond the two considered in this chapter, and there is a great deal yet to learn about the precise effects of those factors and how they interact with each other. Nonetheless, there do not appear to be any problems of principle – just a great deal that is worth exploring further as we try to better understand processing and its role in shaping language and the manner in which it is acquired.

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